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# HYDRODYNAMIC TANK TESTS OF THE ONE-QUARTER-SCALE HARRAH PLANING CRAFT

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GENERAL DYNAMICS | CONVAIR

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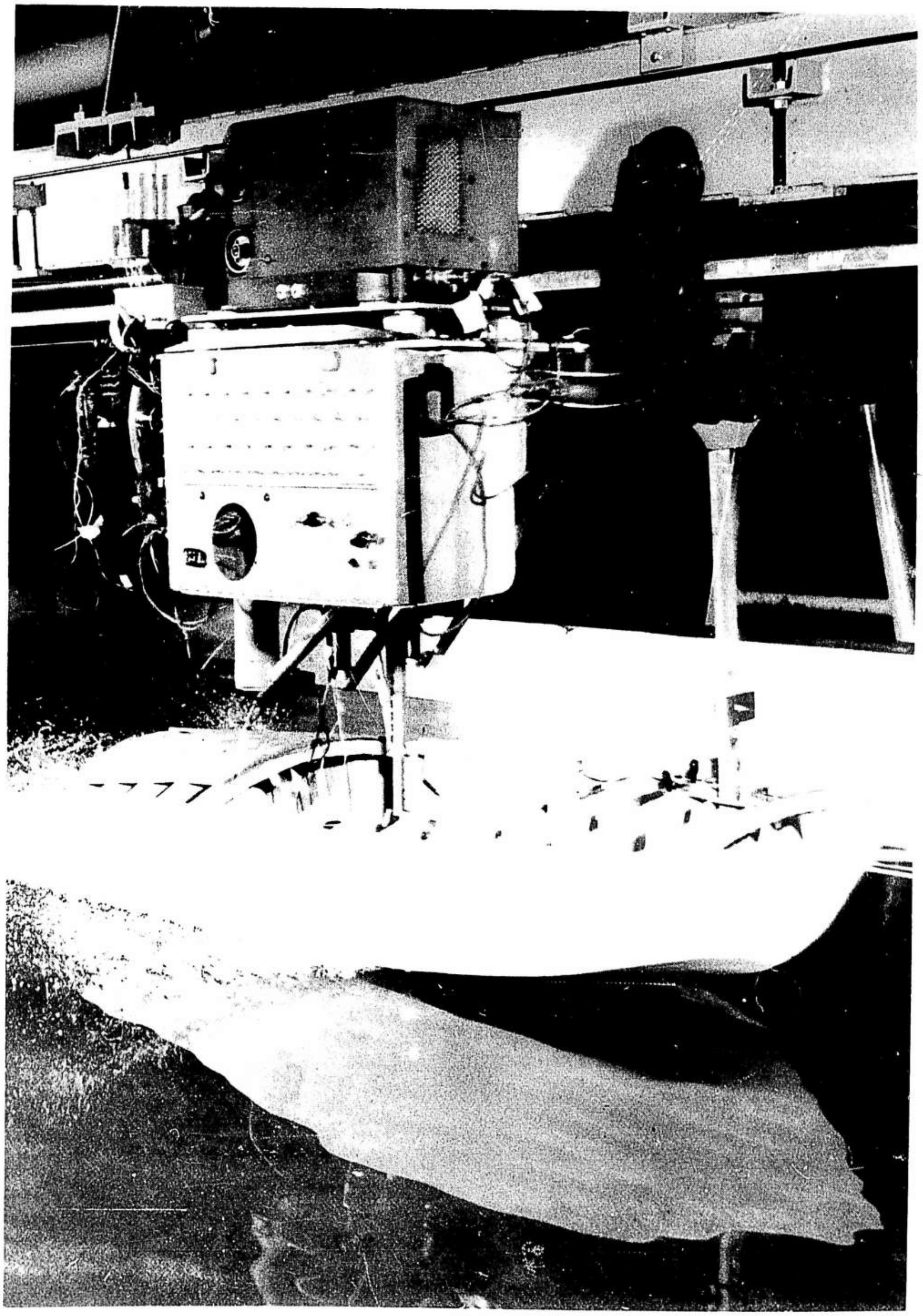


MODEL OF HARRAH PLANING CRAFT IN TOWING TANK AT GENERAL DYNAMICS/CONVAIR HYDRODYNAMIC LABORATORY

# SUMMARY

Presented herein are the results of an experimental study of the Harrah planing craft conducted at the General Dynamics/Convair Hydrodynamic Laboratory in San Diego, California. The object of the study was to determine the cause of adverse yawing, rolling, and pitching attitudes that currently limit the performance of the craft, and to recommend remedies that may enable it to operate up to the design speed of 100 mph.

The study has shown that the adverse motions exhibited by the craft are due not to the hull design (as represented by the model), but rather to powering and ruddering factors. Specifically, these factors are:

1. Steepness of propeller shaft angle.

2. Propeller design.

3. Operation of rudder in propeller cavity.

Recommended remedies include the following:

1. Use of a propeller with higher rake and proper pitch.

2. Reduction of propeller shaft angle.

3. Relocation of rudder away from propeller cavity.

4. Installation of chine strips in bow area.

# CONTENTS



# ILLUSTRATIONS

# INTRODUCTION

The Harrah boat is a planing craft powered by a 1200 hp Allison engine designed to operate at speeds up to 100 mph. To date, however, its intended performance has not met the design specification.

As reported by its owner, the craft has exhibited the following characteristics. It porpoises at speeds in the range of 50 to 60 mph. It heels and yaws to port accompanied by low pitch attitudes at speeds above 60 mph. (A full right rudder, producing yaw to starboard, is required to maintain a straight course.) And finally, the maximum speed attainable is 80 mph.

Prior to this study, the installation of trim plates on the stern of the craft proved a remedy for the porpoising. The undesirable attitude conditions and the low maximum speed, however, remained problems to be solved.

This study was initiated to determine the cause of such adverse yawing, rolling and pitching attitudes, and to find remedies which would enable the craft to operate within the desired speed range.

The model used for testing was supplied by Bill Harrah, Reno, Nevada, the owner of the full-size craft. This model was installed on a dynamic rig which permitted freedom in respect to heave, trim, yaw, and roll. (Figures 2 and 3.) The yaw freedom was limited to ± 5 degrees by a vertical guide. As the model yawed, the warning lights (red on the port side and green on the starboard side), gave a positive indication of the direction of yaw.

A CEC nine-channel oscillograph was utilized to record the continuous history of the trim, heave, drag, and velocity for each of the test runs. High-resolution potentiometers served to monitor the trim and heave, while a strain-gaged deflection beam measured the drag.

# DISCUSSION

The objectives of this study were approached by (1) evaluation of the basic hull design; (2) simulation of the yaw, roll, and pitch attitudes of the craft in the speed range of 60 to 80 mph; and lastly (3) by remedying the conditions of the second objective through modifications (i. e., chine strips).

## BARE HULL TESTS

Initial tests were conducted to determine the soundness of the basic hull design. The tests were made at constant speeds up to 80 mph (full scale) with three center of gravity locations (9.5, 8.45, and 7.95 feet measured from the transom with and without the trim plates). The model showed porpoising without the trim plates in the speed region above 50 mph (full scale). However, in every condition the model failed to roll or yaw.

Figures 5 and 6 show the craft characteristics with and without trim plates plotted versus speed. It is seen in Figure 5 that the craft shows a higher hump trim, 5 degrees as compared to 4 degrees without the trim plates. The hump is also delayed by approximately 16 mph without the plates. The power requirement is presented in Figure 6. A higher power requirement is needed without the trim plates for speeds up to 70 mph. In the speed region above 70 mph, the power requirement is the same for either configuration.

## SIMULATED TESTS

It was conceivable that the initial rolling was a consequence of the propeller torque, and the yawing a consequence of the walking tendency of the propeller. A spring was placed on the model from the towing rig to simulate the propeller torque, thus rolling the model at 4 degrees. Tests at constant speed were again made with the trim plates for the center of gravity location at 8.45 feet from the transom. The model exhibited no yawing tendencies.

Initial yaw of 2 degrees was then put on the model and the tests were repeated. Under these conditions, the model continued to yaw until restricted by the yaw guide. During these tests, water was observed to flow over the rounded chine at the bow. The model did not exhibit any nose-down pitching tendencies.

Tests were then made with the model rolled at 4 degrees without initial yaw. Nose-down moments were applied by placement of weights at the bow. In this manner the low trim attitude was simulated. Without the initial yaw, however, no yawing instability was observed.

# CONCLUSIONS AND RECOMMENDATIONS

The results of this study indicate that the craft hull design as represented by the model is sound, and that the reasons for the adverse rolling, yawing, and pitching motions lie primarily in the powering and ruddering systems.

It is felt that the remedies to obtain good performance characteristics may be found in the control of the initial unbalance of forces applied to the craft by the aforementioned systems.

The adverse nose-down moment may be corrected by the use of a propeller with a higher rake and with proper pitch. A reduction of the propeller shaft angle is also recommended.

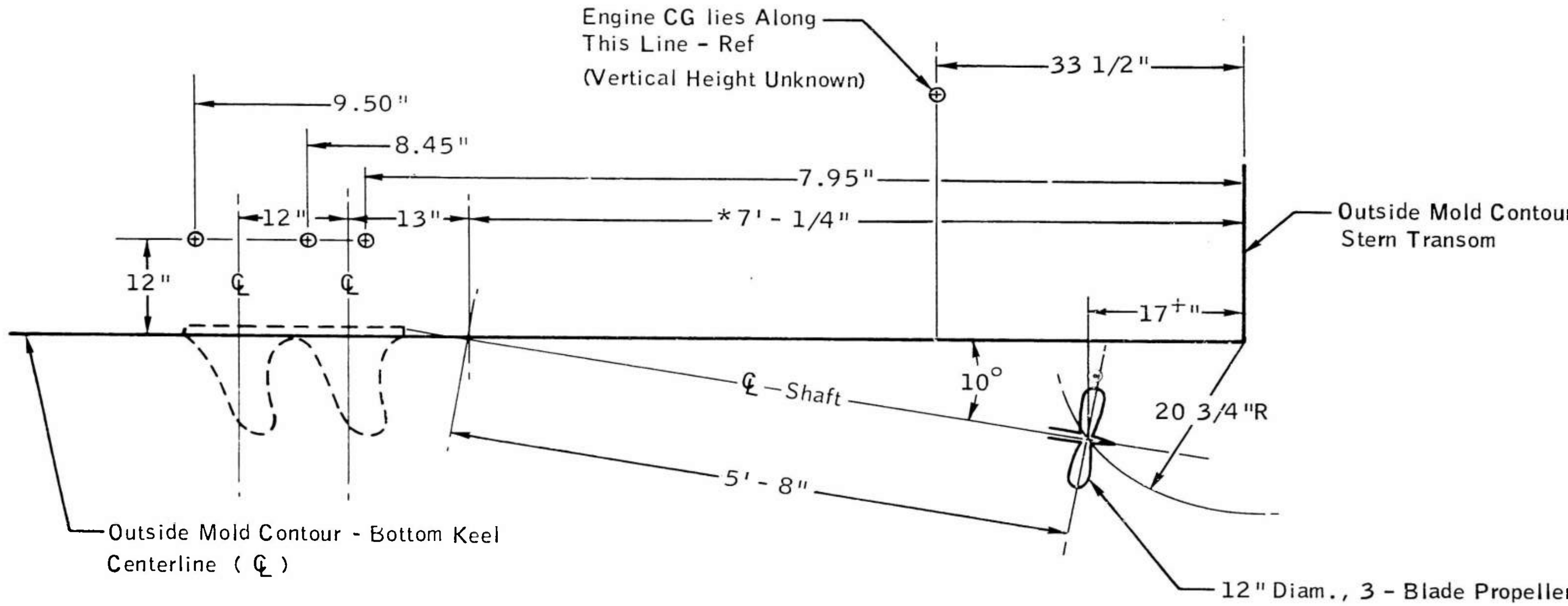
It is further recommended that the rudder be located away from the propeller cavity so that the rudder area may be fully effective throughout the speed range.

Spray strips, attached to the hull at the chines, may be utilized to prevent divergent bow-down attitudes, but these are not considered to be a cure for the basic problem.

It is believed that these modifications will serve to measurably improve the operating characteristics of the planing craft. A certain amount of roll and yaw due to torque, however, is unavoidable.

## REFERENCE

1. Lord Lindsay, Naval Architecture of Planing Hulls, Cornell Maritime Press, New York - 1946.




* Dimension Determined from 1/8 size Geometric Layout (all other dimensions given)

⊕ Model CG Locations

Dimensions Shown in Full Scale

**Figure 1. SKEG AND CENTER OF GRAVITY LOCATIONS**

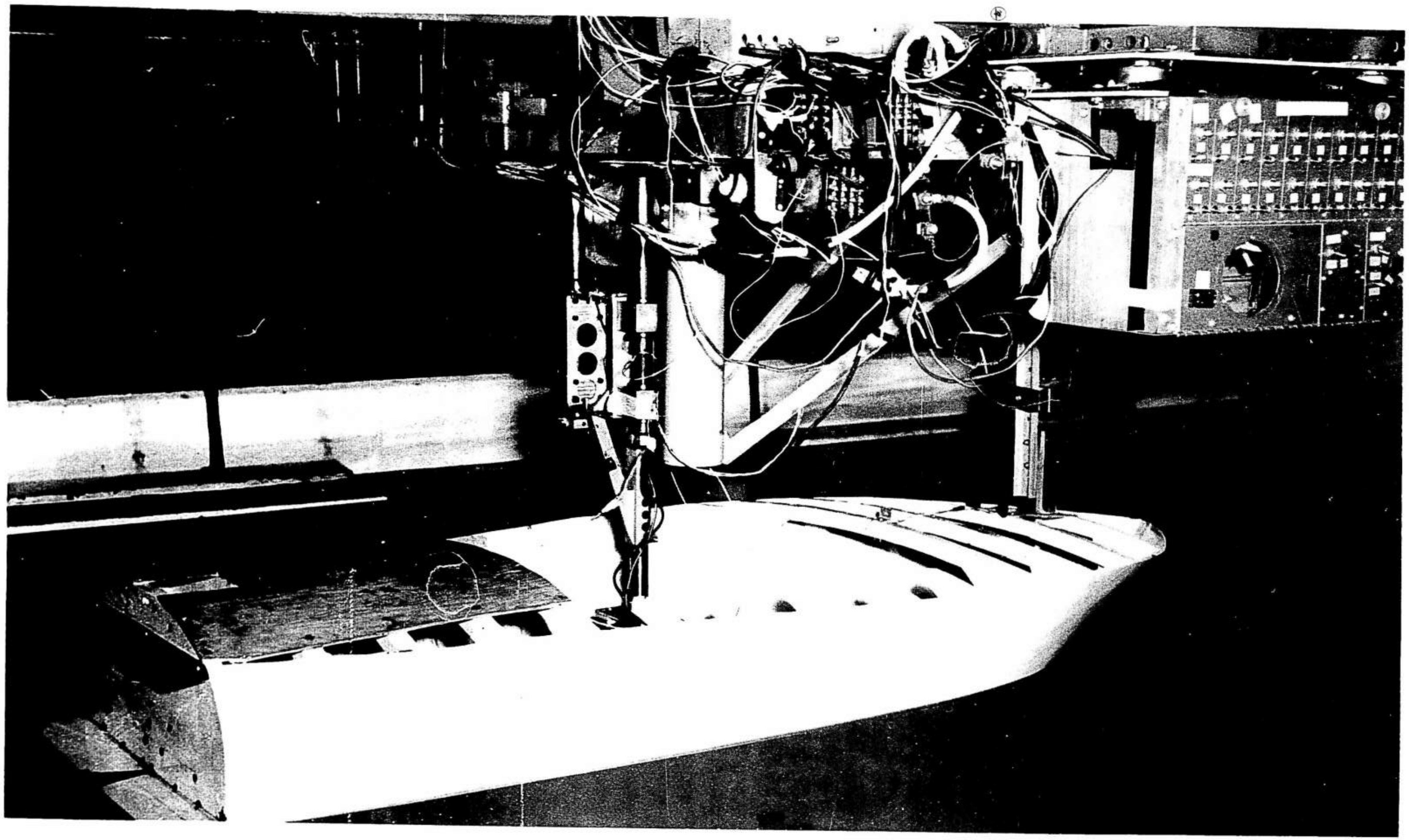


Figure 2. INSTRUMENTATION AND TEST APPARATUS

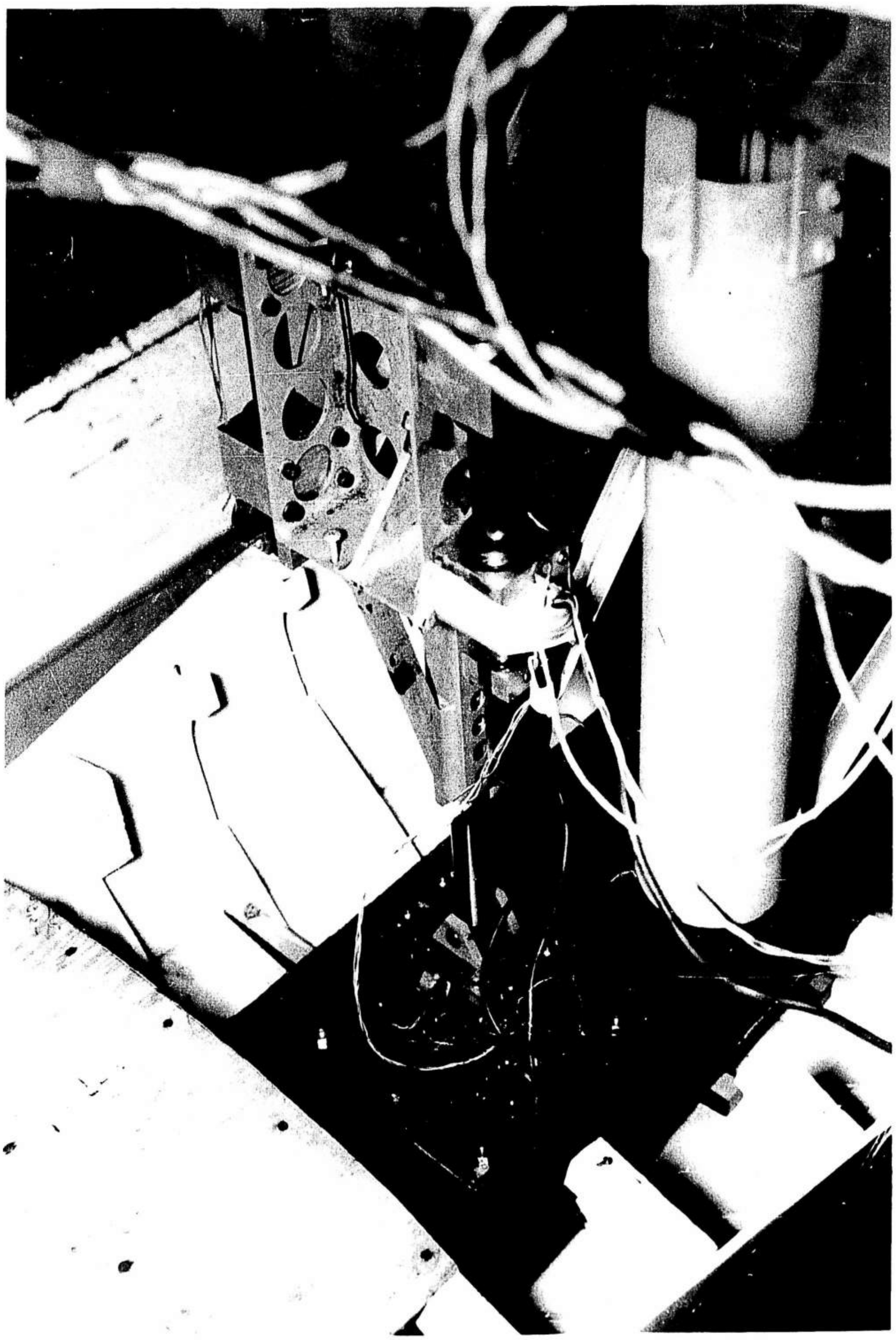


Figure 3. DYNAMIC RIG ASSEMBLY

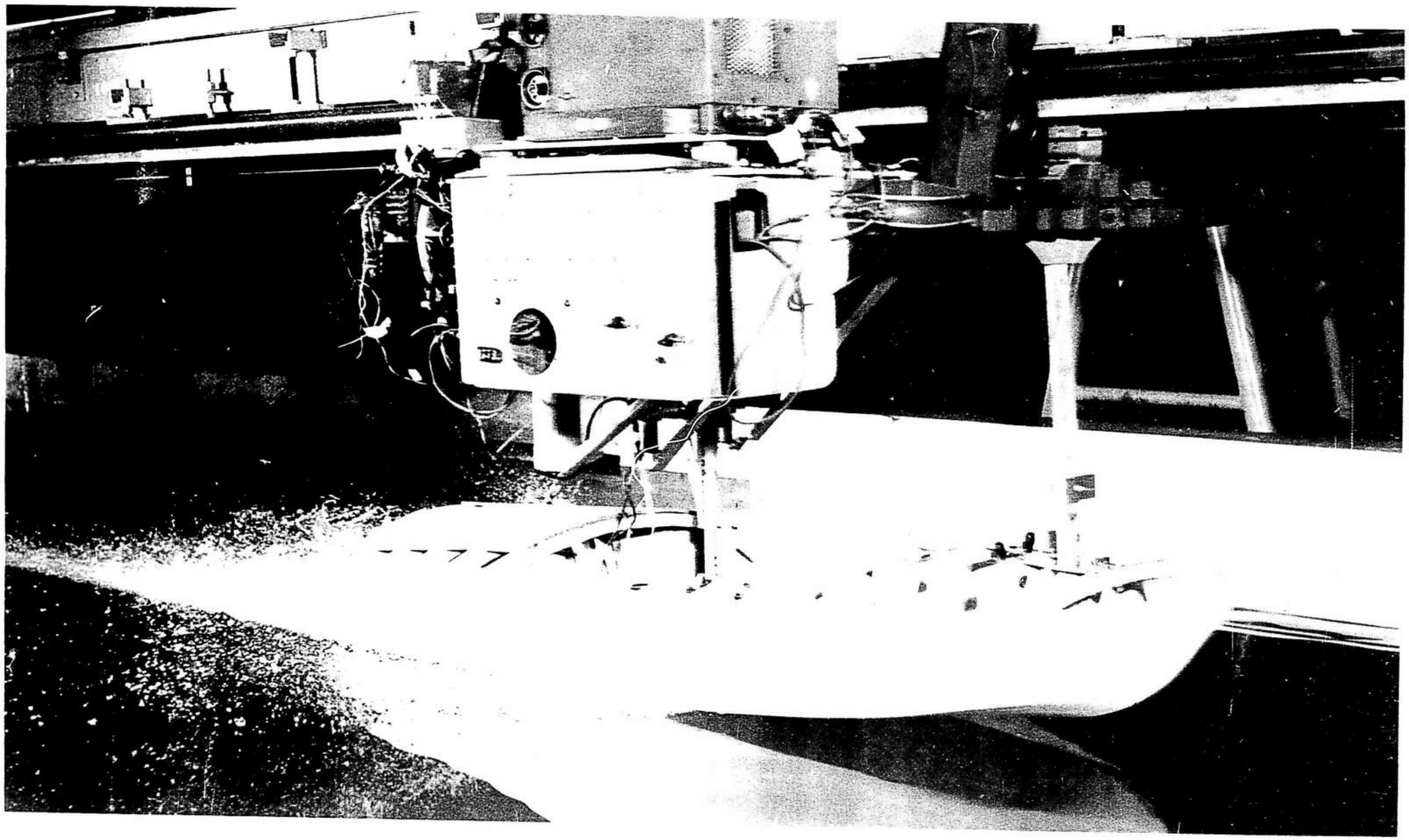


Figure 4. PLANING WITH TRIM PLATES AT 80 MPH

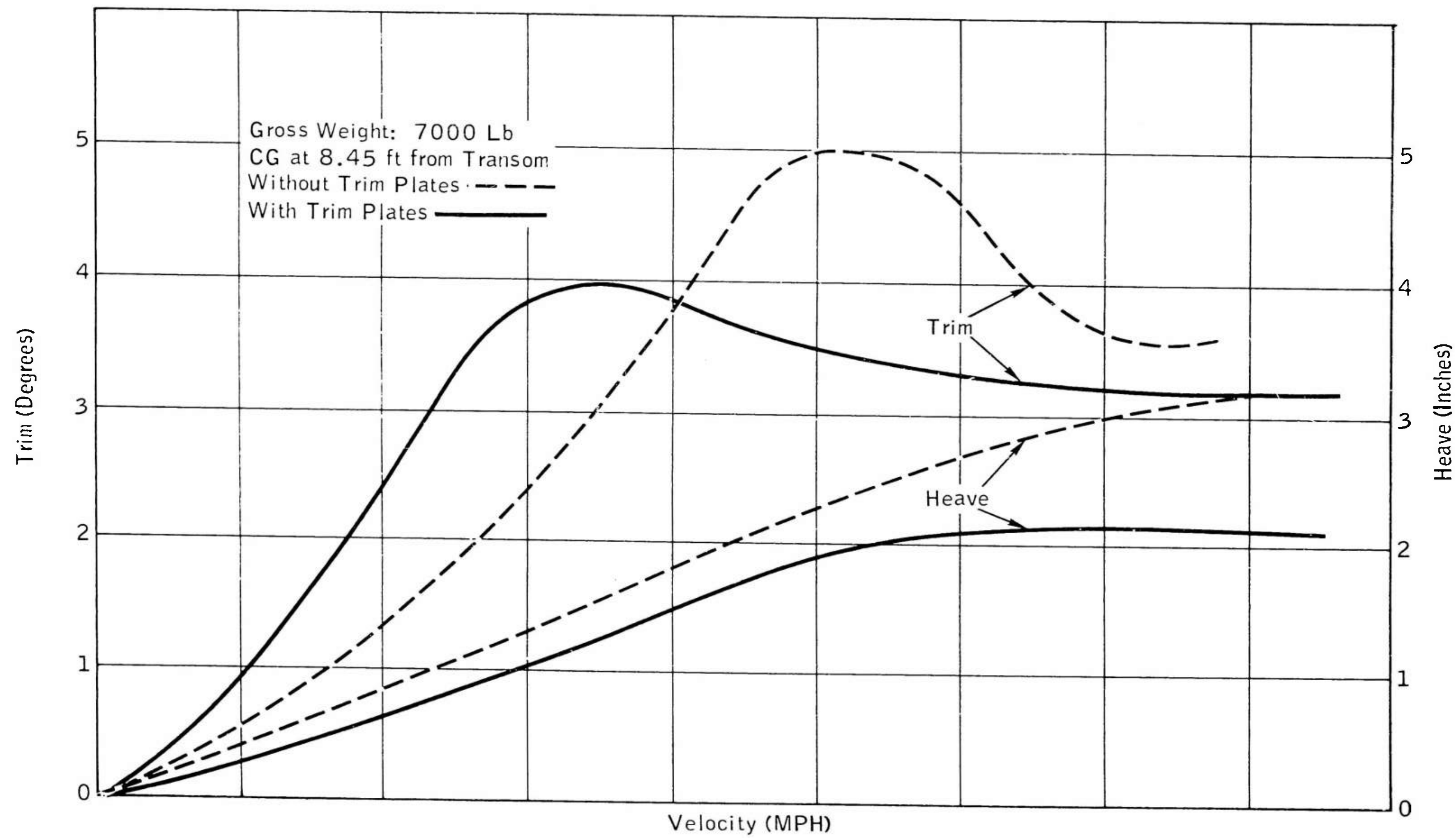



Figure 5. TRIM AND HEAVE CHARACTERISTICS

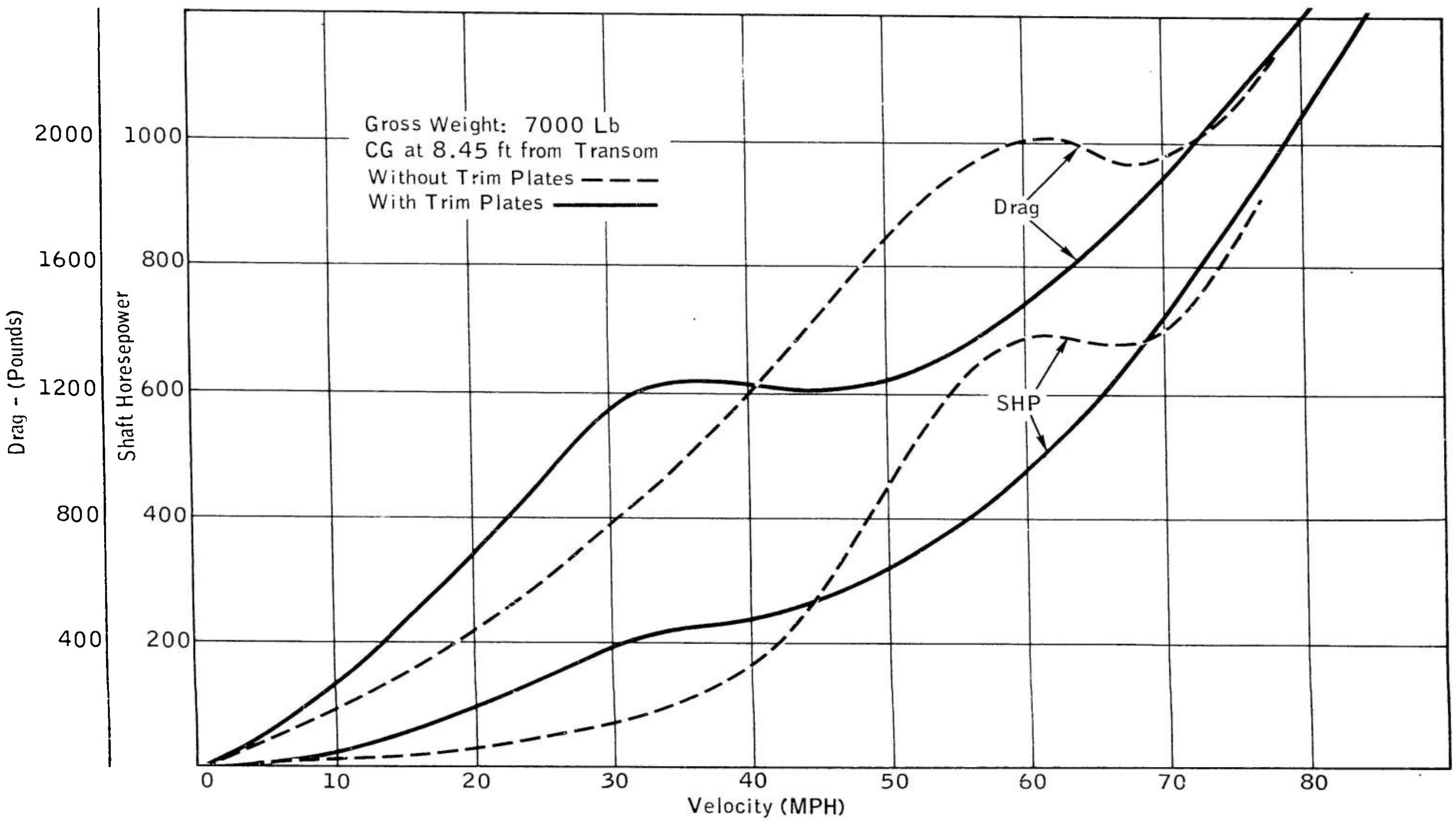



Figure 6. POWER REQUIREMENTS